Remarks

The above Amendments and these Remarks are in reply to the Office Action mailed December 10, 2003.

Claims 1, 3-23, 25, 29, 30, 48-50 were pending in the Application prior to the outstanding Office Action. In the Action, the Examiner rejected claims 1,3-23, 25, 29, 30, 48-50. Applicants acknowledge the withdrawal of the prior rejections of claims 1,3-23,25,29,20 under 35 USC 102(e) and 103(a), Applicants respectfully reinstate all previous remarks herein by reference. The present Response amends claims 1, 3, 22, 25, 48, 49, and 50.

Claims 1, 20, 21, and 48 were rejected under 35 USC 102(b) as being anticipated by Akram et al. (US 5,661,334; hereafter Akram).

Applicants respectfully submit that the amended claim 1, a method for reducing diffusion of dopant ions from a doped dielectric layer into a metal layer, describes a device fabricated by that method that is distinguished from the device of Akram. Akram teaches the fabrication of layers of metal line patterns in devices having inter-metal dielectric structures with low dielectric constant for reducing parasitic capacitance in such devices. The basic device of Akram (Fig. 4-5) is described as, a doped dielectric layer such as BPSG, upon which a barrier layer of silicon nitride or aluminum nitride is deposited, followed thereafter by a layer of the doped dielectric FSG, upon which a silicon nitride or silicon dioxide barrier layer is deposited, then after a subsequent etching step, the deposition of a barrier layer of silicon nitride, upon which a metal layer is deposited, followed the deposition of a barrier layer of preferably silicon nitride, and finally an additional layer of the doped dielectric FSG. The process is repeated to create a bi-level metal structure.

There is nothing, either express or inherent, in Akram that anticipates the device of claim 1, consisting of a substrate layer of undoped oxide dielectric material, a metal layer deposited on the undoped dielectric, upon which metal layer a single diffusion barrier consisting of a metal nitride is then deposited, and then a layer of doped dielectric deposited thereon. Since claims 20 and 21 depend from amended claim 1, it is further submitted that they are patentable for at least the reason given for the parent claim.

Applicants respectfully submit that the amended claim 48, is a structure that is distinguished over

Akram. Akram teaches the fabrication of layers of metal line patterns in devices having inter-metal dielectric structures with low dielectric constant for reducing parasitic capacitance in such devices. Akram does not teach forming a trench having at least one sidewall in a device stack having a metal layer deposited on an undoped dielectric layer, upon which sidewall a single diffusion barrier layer of aluminum nitride is deposited, and then depositing within said trench a layer of doped dielectric material. Akram teaches deposition of a barrier film layer on an interlevel dielectric layer (column 3, lines 27-35), or on top of metal line patterns interspersed with a barrier layer (column 5, lines 32-35; figure 5). The device taught by Akram are characterized by a doped dielectric layer such as BPSG, upon which a barrier layer of silicon nitride or aluminum nitride is deposited, followed thereafter by a layer of the doped dielectric FSG, upon which a silicon nitride or silicon dioxide barrier layer is deposited, then after a subsequent etching step, the deposition of a barrier layer of silicon nitride, upon which a metal layer is deposited, followed the deposition of a barrier layer of preferably silicon nitride, and finally an additional layer of the doped dielectric FSG. The process is repeated to create a bi-level metal structure. There is nothing, either express or inherent, in Akram that anticipates the device of claim 48, consisting of a device stack having a metal layer deposited on an undoped dielectric layer, upon which sidewall a single diffusion barrier layer of aluminum nitride is deposited, and then depositing within said trench a layer of doped dielectric material.

Claim 49 and 50 are rejected under 103(a) as being unpatenable over Akram in view of Tsuneoka, et al.(US 5,060,050, hereafter Tsuneoka). The Action states that Akram teaches substantially the same limitations of claim 49 and 50. Applicants respectfully submit that the devices described in claims 48-50, and characterized and distinguished from Akram in the above for claim 48, are distinguished from Akram.

Regarding Tsuneoka, the Action states that Tsuneoka teaches that silicon nitride and titanium nitride are equivalent diffusion barriers, and refers to the abstract of Tsuneoka. Applicants respectfully submit that, the abstract is not enabling. The written portion of the specification must be referred to for written description and enablement. Referring to Tsuneoka, column 2, lines 58-63, describe diffusion preventative films 20a, 20b, and 20c as made from an electrically-conductive film, such as titanium nitride. Subsequently, diffusion preventative layers 23, 25, 28, 30, and 33, are described in column 3 consistently as a "SiO film formed by plasma CVD;" see column 3, lines 16-20,29-31,42-44,46-48, and 56-59, respectively. Additionally, in column 4, lines 42-45,Tsuneoka states:

"As the diffusion preventative film 23,25,28,30, and 33, it is also possible to employ, for

example, a silicon nitride (SiN) film or alumina (Al_2O_3) film formed by plasma CVD."

Support in the specification for a variety of materials that may be used for a diffusion preventative film relate only to layers 23,25,28,30, and 33, and name silicon oxide, silicon nitride, and alumina. There is no support in the written portion of the specification of Tsuneoka providing that titanium nitride and may be substituted for layers 23,25,28,30, and 33. Further, the rapid, uniform diffusion of fluorine through silicon and silicon oxide is known in the art, and is one attribute that makes fluorine a desirable dopant for specific uses in semiconductor fabrication. Additionally, Applicants submit that it is know in the art that aluminas are good membrane materials, allowing easy diffusion of small moieties, such as fluorine.

Hence, Tsuneoka teaches away from depositing on at least one sidewall of trench in a device stack a diffusion barrier of tantalum or titanium oxide as described in the instant application. Akram teaches a different device than that described in claims 49 and 50, and Tsuneoka teaches away from effective diffusion barriers. There is no motivation to combine Akram and Tsuneoka, and the combination does not teach what is described in the subject application, and claimed in claims 49 and 50.

Claims 4 and 5 stand rejected under 35 USC 103(a) as being unpatenable over Akram in view of Liu, et al. (US 6,080,657, hereafter Liu). The Action states that Akram teaches substantially the limitations of claims 4 and 5, but does not expressly teach wherein the metal nitride layer has a thickness of about 10 to 1000 angstroms or in the range of 50 to about 350 angstroms. The Action cites Liu as disclosing these features (col. 3 lines 23-28).

Claims 4 and 5 are dependent on claim 1. The claim has been amended, and argument has been presented concerning the difference in the device of claim 1 vs. the device of Akram. Additionally, Liu also teaches a different device than that described in claim 1. Specific attention is directed to Liu, figure 6, wherein a metal line created after processing of the metal layer in figure 5 is shown in direct contact with insulating layer 18. Insulating layer 18 is described as composed of silicon dioxide, tetraethoxysilane oxide, borophosphosilicate glass, or the like (column 2, lines 51-55). The structure shown in Fig. 6, therefore, shows a metal surface in direct contact with a doped dielectric layer, unlike the device of claim 1.

Applicant therefore assert that there is no motivation to combine Akram with Liu, and the combination does not describe the device of claim 1 of the instant application. MPEP 2144.05 discusses

obviousness of overlapping ranges, when the ranges themselves are the only element that distinguishes art. Here, the devices themselves are structurally different. Therefore, no prima facie case for obviousness has been presented.

Claims 3 and 22 are rejected under 35 USC 103(a) as being patentable over Akram in view of Tsuneoka and Liu. The Action states that Akram teaches substantially the limitations of claims 3 and 22, but does not expressly the diffusion barrier of a layer of metal oxynitride. The Action states that Tsuneoka teaches that silicon nitride and titanium nitride are equivalent diffusion barriers, and that Liu teaches that titanium oxynitride is a better diffusion barrier that titanium nitride (col 3, lines 29-42). The Action further states that in a similar manner, when oxygen is substituted by nitrogen, nitrogen rich titanium is a more effective diffusion layer.

The claims 3 and 22 of the subject application have been amended similarly to the amendment made for claim 1. Similarly, the arguments presented for claim 1 previously are used to assert that claims 3 and 22 now describe methods creating devices that are different than the devices of Akram. Regarding Tsuneoka, as previously discussed, there is no support in the specification of Tsuneoka for titanium nitride substituting for silicon nitride. Further, since Tsuneoka describes silicon dioxide, alumina, and silicon nitride as materials that can be substituted for diffusion prevention films in the device described therein, Tsuneoka teaches away from providing diffusion barriers of metal nitrides and metal oxynitrides as described in the instant application.

Claim 19, which recites the temperature range for the step of depositing a layer of doped dielectric, is rejected under 35 USC 103(a) as unpatentable over Akram in view of Kwon. Applicants respectfully submit that Kwon teaches a combination of a layer of titanium nitride or titanium with a layer of aluminum oxide, silicon nitride, or silicon oxynitride, which are between a metal layer and a doped dielectric layer. Kwon does not teach the device of claim 1, which is a substrate layer of undoped oxide dielectric material, a metal layer deposited on the undoped dielectric, upon which metal layer a single diffusion barrier consisting of a metal nitride is then deposited, and then a layer of doped dielectric deposited thereon. Therefore, Kwon does not render claim 1 obvious. Applicants respectfully refer to the previous argument presented for how the device of claim 1 is distinguished from the device of Akram.

Neither Akram nor Kwon teach the device of claim 1 of the instant application. There is no motivation to combine Akram with Kwon, and the combination would not result in the device of claim 1 of the subject application. Since claim 19 depends on claim 1, Akram and Kwon either separately or in

combination does therefore not render claim 19 obvious under 35 USC 103(a) for at least the same reason.

Claims 6-13, 16-18, 23, and 25 stand rejected under 35 USC 103(a) as being unpatentable over Akram in view of Liu et al. (US 6080657; hereafter Liu) or in view of Tsuneoka and Liu, and further in view of Lu et al. (US 6365517; hereafter Lu). The Action states that Akram, the combined teachings of Akram and Liu, or Akram, Tsuneoka, and Liu teach substantially the limitations of the above claims, but does not teach expressly the dielectric is doped, a barrier layer of 100 angstroms, and the details about the plasma. The Action states that the missing limitations are taught in Lu.

Claims 6-13, 16-18 depend from claim 1, and claim 23 depends from claim 22. Independent claims 1, 22, and 25 have been amended to distinguish them from Akram, and the arguments have been presented. Additionally, Tsuneoka and Liu have been reviewed in the above, and argued to be, both separately and in combination with Akram to distinguished from what is taught in claims 1 and 22 of the instant application. These arguments extend to amended claim 25.

Further, Lu teaches the chemical deposition of TiN, $TiSi_xN_y$, and TiN_xB_y over insulating layers to protect the insulating layers from metal contamination in a subsequent step of deposition of metal onto an insulating layer (column 4, lines 36-43). There is nothing in Lu that teaches a substrate layer of undoped oxide dielectric material, a metal layer deposited on the undoped dielectric, upon which metal layer a single diffusion barrier consisting of a metal nitride or a single nitrogen rich metal nitride layer is then deposited, and then a layer of doped dielectric deposited thereon, such as described in claims 1 and 22 of the subject application. The chemical deposition of TiN, $TiSi_xN_y$, and TiN_xB_y on a dielectric layer is a different structure than that which is taught in the subject application, and addresses a completely different problem.

Therefore there is nothing in Arkam, Tsuneoka, Liu, or Lu, either separately or in combination that teaches what is described in claims 1, 22, and 25 of the subject application. Since claims 6-13, and 18-23 depend from amended claim 1, and since claim 23 depends on claim 22, it is submitted that they are patentable for at least the reason given for the parent claims.

Additionally, Applicants request that the rejection of dependent claims 14 and 15 under 35 USC 103(a) be withdrawn for essentially the same argument presented for claims 6-13, and 18-23. Since it has been asserted repeatedly that amended claim 1 is a different structure than that of Akram or Lu, either

separately or in combination, and since Inoue does not further teach or suggest the structure made by the method of claim 1, then claim 1 is patentable over Akram in view of Lu in further view of Inoue. Claims 14 and 15 depending on claim 1 are therefore patentable for at least the same reason.

Claims 29 and 30 are rejected under 35 USC 103(a) over Akram in view of Applicants' admitted prior art. As previously stated, Akram does not teach a substrate layer of undoped oxide dielectric material, a metal layer deposited on the undoped dielectric, upon which metal layer a single diffusion barrier consisting of a metal nitride is then deposited, and then a layer of doped dielectric deposited thereon. Further, Applicants' paragraph 78 states, "The nitride can be manufactured in any convenient fashion." The mere existence in the art of a nitride layer does not teach or suggest the use of such a layer to prevent the problem of the contamination of metal layers by dopants from doped dielectric layers. There is no motivation to combine Akram and the art broadly referred to in paragraph 78 of the subject application.

Conclusion

In light of the above amendments, and arguments set forth, it is respectfully submitted that all of the claims now pending in the subject patent application should be allowable, and a Notice of Allowance is requested. The Examiner is respectfully requested to telephone the undersigned if she can assist in any way in expediting issuance of a patent.

Respectfully submitted,

Date: March 10, 2004

By: _____
D. Benjamin Borson, Ph.D.
Reg. No. 42,349

Fliesler Meyer LLP
Four Embarcadero Center, Fourth Floor
San Francisco, California 94111-4156
Telephone: 415/362-3800